The Center for Hospitality Research

Hospitality Leadership Through Learning

Cornell Hospitality Report

Hotel Sustainability Benchmarking

by Howard G. Chong, Ph.D., and Eric E. Ricaurte

Published in conjunction with the Cornell Center for Real Estate and Finance

Vol. 14, No. 11
May 2014

SHA

Cornell University
School of Hotel Administration

Cornell Hospitality Report
Vol. 14, No. 11 (May 2014)

Cornell Hospitality Report is produced for the benefit of the hospitality industry by The Center for Hospitality Research at Cornell University.

Michael C. Sturman, Academic Director
Carol Zhe, Program Manager
Glenn Withiam, Executive Editor
Alfonso Gonzalez, Executive Director of Marketing and Communications

Center for Hospitality Research
Cornell University
School of Hotel Administration
537 Statler Hall
Ithaca, NY 14853

607-255-9780
chr. cornell.edu

Advisory Board

The Center for Hospitality Research

Hospitality Leadership Through Learning

Thank you to our generous Corporate Members

Senior Partners

Accenture
Carlson Rezidor Hotel Group
SAS
STR
Taj Hotels Resorts and Palaces

Partners

Access Point
CVENT
Davis & Gilbert LLP
Deloitte & Touche USA LLP
Denihan Hospitality Group
Duetto
Forbes Travel Guide
Four Seasons Hotels and Resorts
Fox Rothschild LLP
Hilton Worldwide
Host Hotels & Resorts, Inc.
Hyatt Hotels Corporation
Intel Corporation
InterContinental Hotels Group
Jumeirah Group
Marriott International, Inc.
McDonald's USA
priceline.com
PricewaterhouseCoopers
Proskauer
RateGain
ReviewPro
Revinate
Sabre Hospitality Solutions
Sathguru Management Consultants (P) Ltd.
Talent Plus
Tata Consultancy Services
TripAdvisor
Wipro EcoEnergy
Wyndham Hotel Group

Friends

Cleverdis • DK Shifflet & Associates • EyeforTravel • Hospitality Technology Magazine • HRH Group of Hotels Pvt. Ltd. • HSyndicate • International CHRIE • iPerceptions • J.D. Power • The Leela Palaces, Hotels & Resorts • The Lemon Tree Hotel Company • Lodging Hospitality • Milestone Internet Marketing • MindFolio • Mindshare Technologies • The Park Hotels • PKF Hospitality Research • Questex Hospitality Group • Sustainable Travel International

Cornell University
School of Hotel Administration

Hotel Sustainability Benchmarking Study

by Howard G. Chong and Eric E. Ricaurte

EXECUTIVE SUMMARY

This report highlights the results of the first Cornell Hotel Sustainability Benchmarking (CHSB) study which focuses on two key components of sustainability: energy usage and carbon emissions. Monthly utility usage from nine major companies and over 2,000 hotels were analyzed. We present information on the ranges of six energy and carbon key performance indicators (KPI) specifically suited to the hotel industry, with detailed results reported for thirty geographic areas. Three key conclusions are **(1)** benchmarks based on local geography and chain scale segment are essential for any resulting analysis to be useful to the hotel industry, **(2)** even for hotels with similar attributes and in the same city, energy per square meter can vary by more than a factor of 5, and **(3)** there is a continued need for data harmonization to quantify additional drivers of energy use.

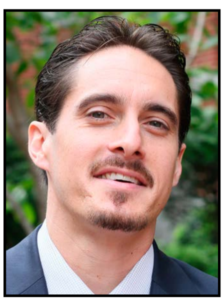
Quick-start Guide

This is a long, detailed report that may be of interest to multiple stakeholders. Here is a guide of how to use this report depending on your role.

- For readers of this study who want to get a carbon number for a room stay, please refer to Exhibits 16 and 18 (pages 23 and 25).
- For readers interested in comparing their property to others in the region using EUIs, refer to Exhibits 20 and 21 (pages 26–27).
- For readers interested in technical measurement issues, pay special attention to the appendix, page 28.
- For readers from a facilities maintenance or HVAC background, pay special attention to the discussion found in the section, "Peak, Heating, and Cooling Use Percentages" (page 16).
- Readers looking for insights on understanding energy and carbon variation across hotels, pay special attention to all the discussion sections, beginning on page 12.

ABOUT THE AUTHORS

Howard G. Chong, Ph.D., is an assistant professor at the Cornell University School of Hotel Administration. His doctorate is in agricultural and resource economics from the University of California, Berkeley. He teaches microeconomics and is developing courses on environmental economics and sustainability. His current research focuses on environmental and energy economics. His past research included studies of energy use in buildings of different ages, the impact of carbon markets on firms, and water markets. He is a faculty fellow at Cornell's Atkinson Center for a Sustainable Future.



A graduate of the Cornell University School of Hotel Administration, **Eric Ricaurte** has helped several global hospitality companies measure and report on sustainability, in addition to his 10 years of experience in operations and consulting in diverse nature and cultural tourism projects globally. Eric is a frequent speaker, organizer, and writer in the topic of sustainability measurement within the industry. Eric is currently a research associate at the Cornell University Center for Hospitality Research, where he focuses on sustainability measurement within hospitality and tourism. His recent industry work includes authoring the Cornell Hospitality Report "Developing a Sustainability Measurement Framework for Hotels: Toward an Industry-wide Reporting Structure" and serving as technical consultant for Phase 1 of the Hotel Carbon Measurement Initiative, a joint program of the International Tourism Partnership and the World Travel & Tourism Council to standardize carbon metrics across the industry. Eric earned a Master of Science degree in Tourism & Travel Management from New York University.

PARTICIPATING ORGANIZATIONS

Hilton Worldwide	**InterContinental Hotels Group**	**Starwood Hotels & Resorts**
Host Hotels & Resorts	**Mandarin Oriental Hotel Group**	**The Hongkong and Shanghai Hotels**
Hyatt Hotels Corporation	**Marriott International**	**Wyndham Worldwide**

Hotel Sustainability Benchmarking Study

by Howard G. Chong and Eric E. Ricaurte

This document presents the results of the first Cornell Hotel Sustainability Benchmarking (CHSB) study of hotel carbon and energy data. To date this research represents the single largest publicly available benchmarking study of hotel energy usage and carbon emissions—one that will continue to evolve each year. The results are presented by geographic market and segmented in alignment with common industry benchmarking practices of occupancy and ADR to lay the groundwork for subsequent benchmarking studies and multivariate regression analysis that is market-specific. In developing industry benchmarks, the aggregate data can be utilized for the benefit of internal and external audiences and to provide a more thorough understanding of attributes affecting energy usage and carbon emissions. Lessons learned can be applied to both internal and external stakeholder audiences with a goal of reducing the environmental impact of hotel operations.

Overview of Findings and Method

The key ideas are shown in the three graphs on this page. Each represents a smoothed histogram of energy use intensity (EUI) with units in kWh per square meter for different subsets of the buildings population.

Exhibit 1

Energy use intensity, U.S. hotels

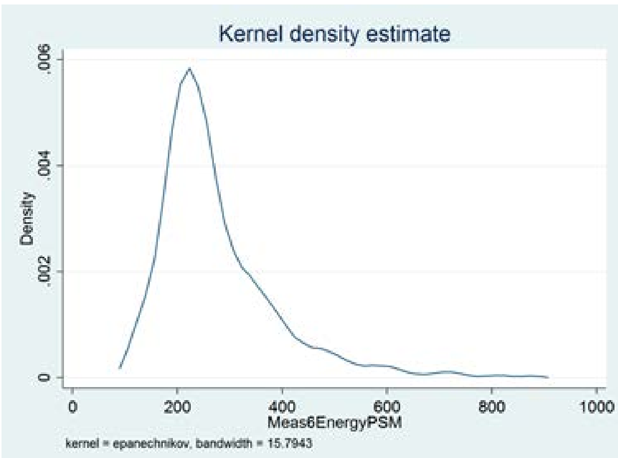


Exhibit 1 shows the distribution of energy intensity for all USA hotels in our sample. As can be expected, there is significant variation across all hotels, with climate being an obvious explanation.

Exhibit 2

Energy use intensity, New York City hotels

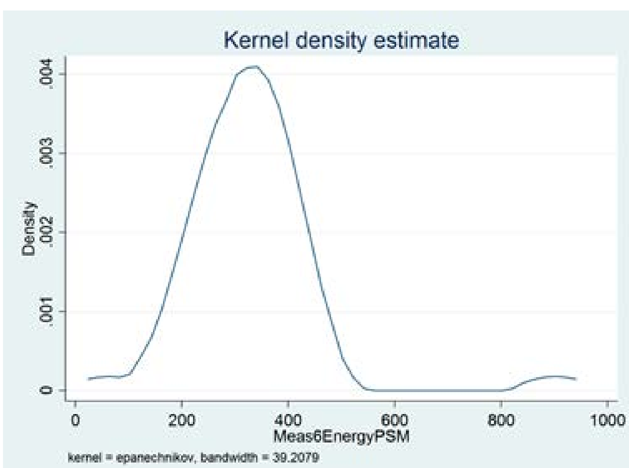
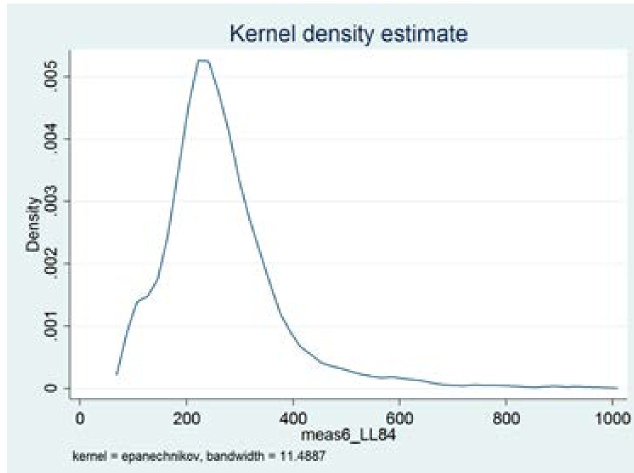


Exhibit 2 shows the distribution for the 47 New York City hotels that are upscale or higher in quality. New York City is a relatively cold location, so the average New York hotel has a higher mean usage than most. More important, though, is the wide range of variation within the city's hotels. These hotels all have the same climate, so temperature is not driving this variation.

Exhibit 3

Energy use intensity, large New York City buildings



Finally, Exhibit 3 shows the distribution for all large buildings in New York as collected by Local Law 84.[1] Note, the peak of the histogram for NYC hotels is further to the right than the peak for the city's buildings. Hence, using all large New York buildings as a reference group would bias evaluation of the hotels. In other words, a uniform energy standard for New York buildings that is insensitive to building use—that is, a standard that does not adjust for hotels versus hospitals or office buildings—would unfairly over-regulate hotels.

Climate is, not surprisingly, a substantial driver of energy use. Exhibit 4, on a later page, shows the variation in energy use across several U.S. cities (y-axis) as compared to the thermal stress of weather as measured in degree-days (x-axis). In contrast to the considerable role of climate in sustainability measures, the correlation between weather and energy use is weak. Corrections for climate or weather should be made carefully. Accordingly, we advocate and present benchmarking specific to each city rather than "heroically" adjusting for climate.

Industry stakeholders can use these data in multiple ways:

- Individual hotel companies can use these data as a continuous improvement tool and replace year-over-year energy metrics which only measure improvement, but not relative property performance. Gains from capital improvements and retrocommisioning will likely be highest in the worst performing buildings.
- The hotel industry can use these data to engage with external regulators, such as the General Services Administration (GSA), Environmental Protection Agency (EPA), or local regulatory boards.
- External stakeholders can use these data for sustainability reporting, regulatory compliance, and to simplify carbon calculation for the hotel portion of travel.

---

1 See: PlanNYC, "Green Buildings & Energy Efficiency," Local Law 84: Benchmarking, www.nyc.gov/html/gbee/html/plan/ll84.shtml.

Study Purpose and Insights

This study was conducted for the following purposes:

- Provide credible benchmarks according to market- and industry-specific segmentation and metrics;
- Conduct valuable industry data analysis while maintaining a confidential data set through an academic center, so that the source data will not be shared with third parties or used commercially; and
- Pursue a common definition and transparent, rigorous method for benchmarking and modeling carbon and energy usage based on hotel-specific attributes and data.

This effort builds on similar studies that have lacked widespread support, sufficient data, industry-specific structure, or transparency and so could not achieve the overall benchmarking goal. This study is a result of several trends, most notably, the current climate of collaboration among industry peers around sustainability measurement and reporting with the common desire to reduce duplication of efforts. Other trends include increased external stakeholder requests and use of sustainability-related performance data, and the increasing technological capacity of global hotel companies enabling the facilitation of data collection with global reach.

This study was undertaken as a collaborative effort among the Cornell University Center for Hospitality Research (CHR), the Cornell University Center for Real Estate and Finance (CREF), Greenview, and the following select global hotel companies:

- Hilton Worldwide,
- Host Hotels & Resorts,
- Hyatt Hotels Corporation,
- InterContinental Hotels Group,
- Mandarin Oriental Hotel Group,
- Marriott International,
- Starwood Hotels & Resorts,
- The Hongkong and Shanghai Hotels, and
- Wyndham Worldwide.

The results of this seminal study revealed several interesting insights:

- Footprints range widely by location and segment, and even within location and segment itself.
- Several opportunities exist to explore quantitatively the drivers in energy beyond occupancy and climate to develop accurate modeling.
- This type of benchmarking exercise will benefit most from common definitions of measurement for all aspects including occupied room counts, floor area, energy usage, and carbon emission factors.

Industry Benchmarking

The value of benchmarking performance against prior years and current competitors, as well as the use of accepted benchmarks at aggregate levels, is proven and widely understood within the hotel industry. Hotel firms use several forms of benchmarking for financial ratios.

Top-line performance data including occupancy, ADR, and RevPAR are the most prevalently benchmarked among hotels across brands and companies. This type of analysis is embedded in industry use for feasibility, appraisals, competitive set analysis, and overall evaluation of a hotel's performance. The basic premise of ADR and occupancy benchmarking is a segmentation first by geographic market and second by chain scale.

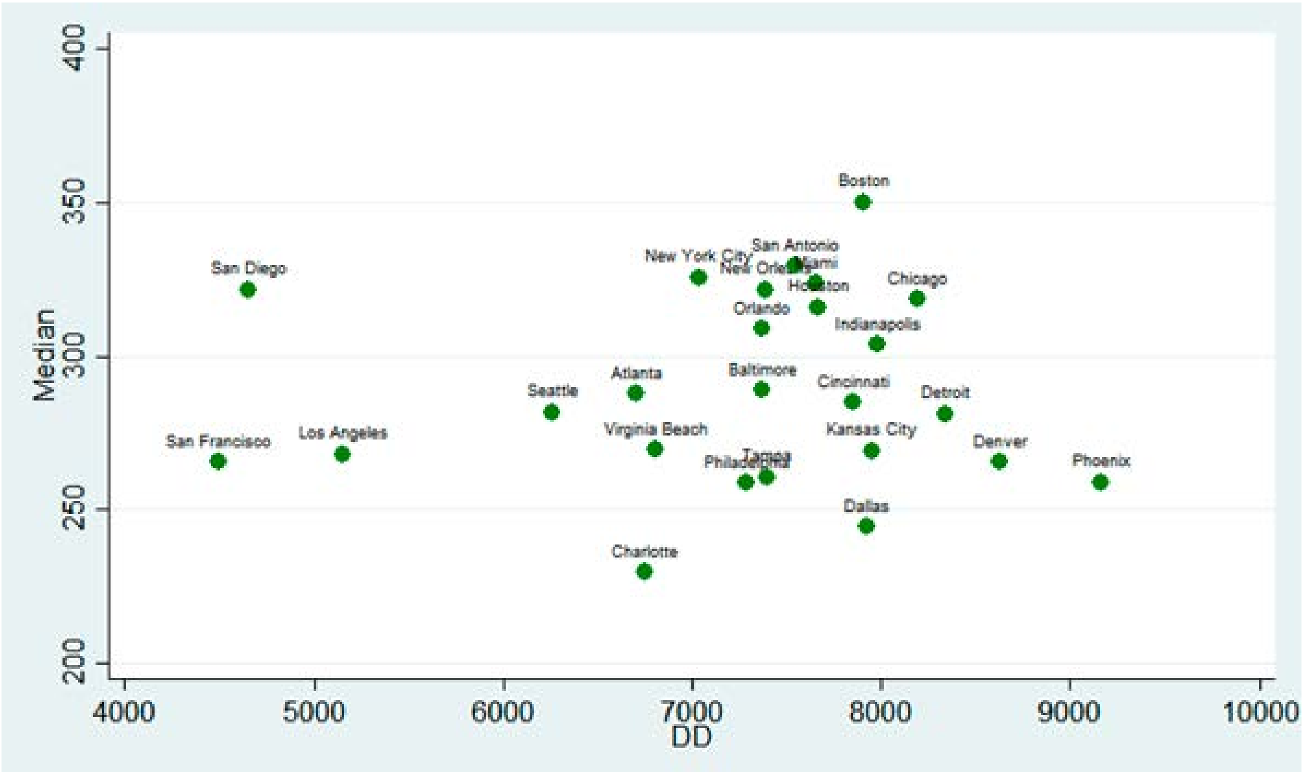
At an aggregate or portfolio-wide level, the differences between ADR or occupancy among markets are relevant when making a decision on where to build, buy, or sell a hotel. Likewise for economic industry analysis, occupancy rates at a city or national level are of interest to compare year over year as a barometer. A hotel company will measure company-wide occupancy and ADR levels in annual reporting, and analyze values across its portfolio that may vary in location and market segment for their own internal purposes.

Benchmarks must make sense. To expand on that point, let's look at some examples of possible benchmarks that wouldn't make sense. Comparing the average RevPAR figures of New York City versus Mexico City, even when adjusted for climate or market differences, may have value for some purposes at the aggregate level, but on a property level it is not necessarily a worthwhile exercise. Similarly for benchmarking performance, it is not relevant for an economy hotel to compare its ADR against that of a luxury hotel within the same market. Thus any type of indexing or normalization for fair share comparison for specific properties is generally considered relevant first by geographic market and second by market segment. Theoretically, rigorous statistical regression analysis could be developed to normalize and enable RevPAR comparisons of an economy hotel and a luxury hotel or a specific hotel in London to a specific hotel in Dubai, but again the value of such an exercise is questionable. It also is not acceptable to industry to force a comparison of two regions; companies wish to select the cities they compare. From the perspective of a customer, a hotel in Dubai and a hotel in London aren't really comparable, regardless of their rates—obviously, geography has a role here. Except in extreme cases of compression or online inventory mismanagement, luxury hotels and economy hotels rarely if ever compete for the same customers either.

Within geographical markets and market segments, indexes and fair share normalization factors make more

Exhibit 4

Energy use intensity compared to thermal stress (in degree days) for major U.S. cities



sense for comparisons and add more value to the user. Factors such as location, amenities, function space, age, and quality of service are the influencers that can be studied and evaluated. A RevPAR index is valuable when used against a hotel's defined competitive set. The same is true for the sustainability benchmarks we present here. We note a substantial increase in benchmarking needs in the field of sustainability, as utility benchmarking requests in particular have increased. Benchmarking has long been valued, practiced, and even mandated in the case of energy consumption in buildings in municipalities, regions, and countries. That trend can only grow.

What we found to date is that when discussions of benchmarking energy usage of hotels emerged, the well-meant efforts generally began by putting "the cart before the horse" in attempting complex regression and modeling to compare wide sets of hotels against one another, without first making the basic distinction of separating hotels out by geographic market and segment. The clearest example is the EPA's Energy Star Portfolio Manager, which developed its Energy Use Intensity (EUI) based on a national data set of 142 hotels.[1] Scoring for these is not tailored or indexed for specific regions, and thus hotels' Energy Star ratings cross geographic market and segment lines. Likewise, academic studies have generally examined energy data within one specific hotel property or one market only, or attempted to apply multivariate regression equations to hotels across markets and segments.[2]

As we noted several attempts at industry-wide benchmarking in both energy and carbon have been attempted.[3] These have been steps in the right direction, but have used limited data sets or cursory calculations. In any event, they have not received widespread industry buy-in or use and they may have clouded the sustainability discussion. At the same time, this dialogue is increasingly important as

---

[1] See: www.energystar.gov/ia/business/evaluate_performance/hotel_tech_desc.pdf

[2] For discussion, see: See: Eric Ricaurte, "Developing a Sustainability Measurement Framework for Hotels: Toward an Industry-wide Reporting Structure," *Cornell Hospitality Report,* Vol. 11, No. 13 (July 2011) Cornell Center for Hospitality Research, pp. 8-16

[3] For further discussion, see: *Ibid.*.

customers purchasing large quantities of hospitality services (e.g., groups and conventions) are requesting the carbon footprint of their stay while demanding consistency and transparency in the calculation methods used. Consequently, carbon footprinting exercises will lead to external uses of benchmarking of carbon among hotels.These trends demonstrate a clear need for globally accepted benchmarks that are **(1)** backed by sufficient, timely data, **(2)** tailored to hotel operations specifically and not as a subset of commercial buildings, **(3)** in alignment with common industry benchmarking structures that focus specifically on geographical and industry segmentation, and **(4)** supported by an industry critical mass.

The need has been voiced for independent data analysis and collaborative industry efforts for operational performance at the Cornell Hospitality Research Summit in 2010 and Sustainability Roundtable in 2011.[4] Several participating companies expressed willingness to submit data to an independent host within the industry. As a precursor, the industry has recently established the Hotel Carbon Measurement Initiative (HCMI), a common protocol on carbon calculation.[5] However HCMI in its current version does not outline a standardized set of emission factors, and this can cause significant variation in a hotel's final carbon metrics. Thus, the need persists for comparable data on energy consumption and carbon emissions within the industry.

With that background, the purpose of this Hotel Sustainability Benchmarking (CHSB) study is to establish a formalized, annual benchmarking program specifically tailored to the global hotel industry. The study's goal is to enable benchmarking of energy and carbon in a similar format to that of ADR, occupancy, and RevPAR. We focused our efforts on obtaining data across companies, with the purpose of compiling a critical mass of hotels in several key geographic markets and diverse market segments. Our goal was to enable basic comparison at a property level and also to provide data at an aggregate level. More important, the study sets out to develop a structure to be improved over time to expand the number of geographic markets and the specific measurements of segments within those markets, as well as to develop normalization methods to enable indexing and fair comparison within markets and segments.

Application of CHSB Data

Long-term, specific opportunities and applications of CHSB data include:

(1) Allowing for internal benchmarking. Hotel properties and companies wishing to compare performance against a general competitive set may use the benchmarks against their own performance. Managers, owners, and lenders may identify poorly performing properties based on the comparison to the median in their market. Low and high values may be used when internally scrubbing data for quality checks.

(2) Improving rating systems. Entities that rank or score hotels based on environmental performance can incorporate benchmarks from the report and quantification methods to tailor their own methodology. For example, the energy benchmarks and properties' positioning can be compared with Energy Star ratings.

(3) Expediting customer carbon footprint calculation. Lodging customers seeking to calculate the carbon footprint of their own hotel stays may make a credible calculation using the CHSB results. This will expedite the calculation, and save corporate travel officers' or event planners' time in acquiring property-specific data for a city or global destination.

(4) Streamlining voluntary carbon-offset programs. Carbon-offset programs can use CHSB figures to develop credible and transparent estimates of carbon footprint values to establish offset levels.

(5) Improving internal modeling. Hotel companies with proprietary benchmarking systems may take into consideration the eventual correlations, regression studies, and lessons learned from each year's study for improving their own internal modeling.

(6) Setting municipal coding and regulation. Entities that wish to benchmark performance specifications of energy or carbon performance in municipalities or regions can use the geographic-specific data from which to benchmark their codes or common thresholds.

(7) Improving country perspectives. In countries without any formalized benchmarking process, the research may fill the gap for basic environmental data uses in these countries in feasibility studies, cost analysis, and payback calculations on retrofits and renovations.

(8) Use for hotel development. Developers and consultants from smaller outfits and even larger firms may be able to use benchmarks in feasibility studies for estimating energy usage and any resulting fees, risks, or opportunities relating to carbon.

---

[4] Eric Ricaurte, "The Hospitality Industry Confronts the Global Challenge of Sustainability," *Cornell Hospitality Roundtable Proceedings,* Vol. 4, No. 1 (February 2012), Cornell Center for Hospitality Research.

[5] For further information on HCMI, see: en.wikipedia.org/wiki/Hotel_Carbon_Measurement_Initiative.

Data Preparation

To set up the CHSB, an advisory group was formed consisting of one representative from each participating company. We found that the foremost challenge in arriving at global benchmarks was consolidating and harmonizing the data sets and carbon calculation across companies, segments, and geographic regions. As issues of measurement arose, the group was engaged through conference calls and surveys. Final decisions on study preparation, however, fell upon the principal investigator.

The advisory group supported the development and testing of a common data request form, allowing for flexibility within each entity to utilize their internally existing data structures. All participating companies were requested to submit floor area, monthly energy consumption by type, monthly occupancy by type, property location, and market segment. A pilot test was performed with select data, presenting the results to the advisory group for review with their corresponding issues, with further surveys and group discussion to finalize issues.

Final data were submitted, and a validity check was returned to all participants, flagging data that lacked a full year's data, exceeded minimum 5 percent or maximum 95 percent thresholds, or demonstrated a questionable variance over the 12-month data set period. Participants corrected data where possible. Information on data preparation and calculation methods can be found in the appendix, page 28.

Results and Tables

Developing benchmarks is a challenging process, as described here. We received data from 4,620 hotels in 112 countries. Of this global data set, 2,922 (63%) hotels were excluded for failing to meet validity tests or missing data. To maintain confidentiality, individual hotel data are not publicly disclosed. Because we report summary statistics only for locations with data available for a minimum of ten hotels, we removed over 500 of the remaining 1,698 hotels, since there were not the minimum ten properties within their geographic location.

The sample size itself is telling of the current situation. The high exclusion rate demonstrates the longstanding challenge of hotel companies across the industry obtaining complete data from their portfolios, given that some are owned, some managed, and many are franchised.[6] Furthermore, although the data sets are global, we still lack of a critical mass of quality hotel data within several geographic areas with comparable drivers of energy and carbon. Even with those caveats, the major milestone should not be overlooked that the data were not collected through property surveys, but from company data sets. To date, this study represents the single largest energy and carbon benchmarking exercise ever undertaken and made publicly available by the hotel industry or a third party. The 1,000-plus hotels in this study form a critical mass to enable benchmarking within full-service hotel segmentation in several key U.S. markets.

Exhibit 5

"Geography" definitions

Region	Geographical elements
Atlanta	Atlanta-Sandy Springs-Roswell, GA
Baltimore	Baltimore-Columbia-Towson, MD
Boston	Boston-Cambridge-Newton, MA, NH
Charlotte	Charlotte-Concord-Gastonia, NC-SC
Chicago	Chicago-Naperville-Elgin, IL, IN, WI
Cincinnati	Cincinnati, OH, KY, IN
Dallas	Dallas-Fort Worth-Arlington, TX
Denver	Denver-Aurora-Lakewood, CO
Detroit	Detroit-Warren-Dearborn, MI
Hong Kong-Shenzhen-Macau	Hong Kong-Shenzhen-Macau
Houston	Houston-The Woodlands-Sugar Land, TX
Indianapolis	Indianapolis-Carmel-Anderson, IN
Kansas City	Kansas City, MO, KS
Los Angeles	Los Angeles-Long Beach-Anaheim, CA
Miami	Miami-Fort Lauderdale-West Palm Beach, FL
New Orleans	New Orleans-Metairie, LA
New York City	New York, NY, Newark-Jersey City, NJ
Orlando	Orlando-Kissimmee-Sanford, FL
Philadelphia	Philadelphia, PA, Camden, NJ, Wilmington, DE
Phoenix	Phoenix-Mesa-Scottsdale, AZ
San Antonio	San Antonio-New Braunfels, TX
San Diego	San Diego-Carlsbad, CA
San Francisco	San Francisco-Oakland-Hayward, CA
Seattle	Seattle-Tacoma-Bellevue, WA
Tampa	Tampa-St. Petersburg-Clearwater, FL
Virginia Beach	Virginia Beach-Norfolk-Newport News, VA, NC
Washington, DC	Washington, DC, Arlington-Alexandria, VA, MD, WV

Tables

Using a threshold of 10 properties,[7] data were collapsed into what are termed "geographies," which constitute a metropoli-

6 Note that these issues are not specific to hotels. Several cross-industry efforts exist to simplify and automate data collections. For example, see: energy.gov/data/green-button.

7 A lower threshold was used for Hong Kong, Shenzhen, and Macao.

Exhibit 6

Cities' energy footprints (kWh/m2), in ascending order of median EUI

Region	Median	SD	CDD	HDD
Charlotte	229.4	72.6	3,983.0	2,769.0
Dallas	244.2	76.0	6,144.0	1,781.0
Philadelphia	258.3	92.6	2,730.0	4,560.0
Phoenix	258.6	69.2	8,178.0	983.0
Tampa	260.5	78.2	6,952.0	445.0
San Francisco	265.4	62.6	1,209.0	3,283.0
Denver	265.5	98.1	2,950.0	5,678.0
Los Angeles	267.8	136.2	3,761.0	1,388.0
Kansas City	269.0	76.2	3,963.0	3,989.0
Virginia Beach	269.3	109.7	4,256.0	2,546.0
Detroit	281.1	66.0	2,417.0	5,920.0
Seattle	281.7	37.8	845.0	5,414.0
Cincinnati	284.7	55.5	3,130.0	4,720.0
Atlanta	287.5	79.4	4,176.0	2,531.0
Baltimore	288.7	64.9	4,298.0	3,070.0
Indianapolis	303.7	63.7	3,117.0	4,863.0
Orlando	308.7	78.7	7,055.0	315.0
Houston	315.9	138.4	6,823.0	840.0
Chicago	318.5	101.6	2,865.0	5,330.0
San Diego	321.5	116.1	3,261.0	1,391.0
New Orleans	321.6	49.4	6,578.0	812.0
Miami	323.7	82.0	7,408.0	252.0
New York City	325.5	136.5	2,864.0	4,170.0
San Antonio	329.2	91.9	6,321.0	1,228.0
Boston	350.0	118.0	2,193.0	5,712.0

tan statistical area, country, or region. As shown in Exhibit 5, results for a total of 30 geographies are presented in the tables. Analyzed 2012 calendar-year data for each geography are presented according to the following six metrics:

(1) HCMI rooms carbon footprint per occupied room (Exhibit 16, page 22). Using the Hotel Carbon Measurement Initiative (HCMI) methodology as a reference, these values represent the HCMI metric corresponding to the apportioned rooms footprint of each hotel.[8]

[8] Due to incomplete data on the presence of onsite laundry wash within the sample, no allocation was made for outsourced laundry wash, as explained below.

This metric is useful in calculating the carbon footprint of a hotel stay from the guest's perspective.

(2) Hotel carbon footprint per room (Exhibit 17, page 23). The total greenhouse gas (GHG) emissions of the hotel divided by the total number of rooms, without factoring in occupancy or floor area.

(3) Hotel carbon footprint per occupied room (Exhibit 18, page 24). The total GHG emissions of the hotel divided by the total number of occupied rooms. Occupied rooms are rooms sold plus comp rooms, minus no-shows.

(4) Hotel carbon footprint per square meter (Exhibit 19, page 25). The total GHG emissions of the hotel divided by the total area of conditioned space, expressed in square meters.

(5) Hotel energy footprint per occupied room (Exhibit 20, page 26). The total energy consumption of the hotel divided by the total number of occupied rooms. Occupied rooms are rooms sold plus comp rooms, minus no-shows.

(6) Hotel energy footprint per square meter (Exhibit 21, page 27). The total energy consumption of the hotel divided by the total area of conditioned space, expressed in square meters.

For each metric, values are broken down in the following ways:

- **Count**—the number of properties included within this geography and segment grouping;
- **High**—the highest value found within the geography segment grouping (this is the *worst* performer of the group);
- **Median**—the middle value found within the geography and segment grouping;
- **Low**—the lowest value found within the geography segment grouping (this is the *best* performer of the group); and

- **SD**—the standard deviation across the hotels within the data set.

Discussion

Data analysis reveals several nuances specific to hotels and calculation methods which will need to be further harmonized for accurate modeling in subsequent studies. Furthermore, results demonstrate specific characteristics that should be taken into consideration when performing benchmarking or footprinting exercises.

As discussed next, some key energy drivers were visible within the data, while others remain speculative and require the gathering of further variables in future studies. Among the drivers are climate and weather, laundry procedures, room size, and renewable energy.

Exhibit 7

Cities' energy footprint, in ascending order of degree days

Region	Median	SD	CDD	HDD	DD
San Francisco	265.4	62.6	1,209.0	3,283.0	4,492.0
San Diego	321.5	116.1	3,261.0	1,391.0	4,652.0
Los Angeles	267.8	136.2	3,761.0	1,388.0	5,149.0
Seattle	281.7	37.8	845.0	5,414.0	6,259.0
Atlanta	287.5	79.4	4,176.0	2,531.0	6,707.0
Charlotte	229.4	72.6	3,983.0	2,769.0	6,752.0
Virginia Beach	269.3	109.7	4,256.0	2,546.0	6,802.0
New York City	325.5	136.5	2,864.0	4,170.0	7,034.0
Philadelphia	258.3	92.6	2,730.0	4,560.0	7,290.0
Baltimore	288.7	64.9	4,298.0	3,070.0	7,368.0
Orlando	308.7	78.7	7,055.0	315.0	7,370.0
New Orleans	321.6	49.4	6,578.0	812.0	7,390.0
Tampa	260.5	78.2	6,952.0	445.0	7,397.0
San Antonio	329.2	91.9	6,321.0	1,228.0	7,549.0
Miami	323.7	82.0	7,408.0	252.0	7,660.0
Houston	315.9	138.4	6,823.0	840.0	7,663.0
Cincinnati	284.7	55.5	3,130.0	4,720.0	7,850.0
Boston	350.0	118.0	2,193.0	5,712.0	7,905.0
Dallas	244.2	76.0	6,144.0	1,781.0	7,925.0
Kansas City	269.0	76.2	3,963.0	3,989.0	7,952.0
Indianapolis	303.7	63.7	3,117.0	4,863.0	7,980.0
Chicago	318.5	101.6	2,865.0	5,330.0	8,195.0
Detroit	281.1	66.0	2,417.0	5,920.0	8,337.0
Denver	265.5	98.1	2,950.0	5,678.0	8,628.0
Phoenix	258.6	69.2	8,178.0	983.0	9,161.0

Climate Factors

Climate clearly plays a role in energy use for hotels. In this discussion of the study results, we present data suggesting caution for methods of adjusting for climate in building energy benchmarking, referring back to Exhibit 4. Exhibits 6 and 7 take the median EUI (Measure 6) for several U.S. cities and plots or reports these values against degree-day measures. Cooling degree-days (CDD) and heating degree-days (HDD) are measures of the amount of cooling and heating load for buildings in each city. This is the genesis of the plot in Exhibit 4.

Several results suggest that climate needs to be considered carefully. First, there is surprisingly no statistically significant relationship between energy usage and cumulative degree-days.[9] Hence, a linear correction for degree-days would create problems.[10] There are many potential technical reasons for this non-relationship, including the impact of moisture and humidity, the differential energy intensity of cooling and heating services, within-city temperature variation, and differences in building age and characteristics. Second, even when comparing cities with similar DD measures (e.g., those cities between 7,000 and 8,000 degree-days), there is significant variation. Philadelphia, Boston, and Baltimore all have similar climates but different means, as shown in Exhibit 8 (following page). Third, the cities with the lowest energy use intensity are surprising. Charlotte and Dallas have a lower median EUI than San Francisco does, despite having much higher thermal loads. To aid in comparison, two tables are provided here: one sorted by EUI (Exhibit 6) and one sorted by cumulative degree days (Exhibit 7).

9 We use degree days (DD) as the sum of cooling degree days and heating degree days.

10 A similar regression on CDD and HDD separately also produces no clear pattern across cities. The Energy Star program for buildings corrects for weather using a linear adjustment in EUI for HDD and CDD.

Exhibit 8

Comparison of weather and climate effects

City	Climate (~30yr) HDD65	2012 Weather HDD65	Comment
Baltimore	4,567	3,070	2012 was much less cold than normal.
Boston	5,621	5,712	2012 was slightly colder than normal.
Philadelphia	4,579	4,560	2012 was very close to normal in coldness.

Source: 2009 ASHRAE Fundamentals, Chap 14.; HSB data

A second important thing to note is the need to correct for weather rather than climate. Climate is defined as the average meteorological conditions over a long time horizon, often about 30 years. Weather is what actually occurs in a specific year. EUIs which are built on energy data from a given year must be corrected for with the weather data of that year; using climate would be incorrect. In this study, we correct for weather.

The differences between weather and climate are demonstrated in Exhibit 8, in which the comparison of HDD demonstrates the severity of the three cities' winter weather. Boston had a slightly more severe winter than usual, but Baltimore had a much less severe winter than normal. Despite being a one-hour drive from each other, Baltimore and Philadelphia experienced markedly different winters in 2012 in terms of heating needs. Examples like this support the argument put forth by industry to not make comparisons on broad geographic areas based on climate zones (which are based on climate, not weather).

Wide Variation in Energy Usage

The most apparent observation from the data is that energy use values are "all over the map," with wide variations and a handful of outliers. The outliers may be large properties with particular amenities, highly inefficient fuel sources, or inefficient use of energy. While these hotels are several standard deviations away from the mean, they demonstrate that some hotels may have large footprints. These hotels with high footprints exist in many geographies and are not just statistical anomalies. For example, it was apparent that the luxury sector on average has a higher energy use per square foot than other full-service hotels. Nevertheless, because of data constraints this segment was collapsed into the same grouping as upscale hotels. Likewise, the upper midscale segment demonstrates a wide range of footprint values within the segment itself, as the segment demonstrates the widest range in its total floor area, amenities, and location among the data set.

Wide ranges in energy use have been demonstrated in other instances of building data within specific geographies. In Exhibits 1, 2, and 3, we showed energy data obtained through New York City's Local Law 84, which requires commercial buildings larger than 50,000 square feet to report energy usage annually. The 2013 data set of over 8,000 properties shows a range between 0 and 89,000 kBtu per square foot. Working with this data set to discard extreme outliers and obvious data errors, the range is from 30 kBtu/sq.ft. to 531 kBtu/sq.ft, indicating variation by a factor of ten. In the case of residential buildings, a U.S. Department of Energy study in the Pacific Northwest used a control sample of 91 houses identical in design and similar in construction and found that even within these essentially identical homes' energy use varied by more than a factor of four.[11]

Thus even if two buildings within the same hotel segment use different amounts of energy, it may be based upon differences in the buildings themselves or differences in building use. Drivers of the energy variation in hotels are generally known: restaurants, conference facilities, building envelopes, size and layout of public areas, design of the hotel, specific amenities or equipment, type of equipment, FF&E specifications, operating practices, occupancy and space utilization, and even micro-climates within geographies—any of these may influence energy use.[12] Hence, even if one building has a higher EUI than another building, it is not correct to infer that it is less energy efficient.

We were not able to collect data on all these property attributes for this first study, but future research aims to include running analyses of the impact of some of these factors on energy use. We did request information on one particular variable, namely, laundry wash, and this allowed at least a partial analysis (limited by data quality constraints). Fortunately, hotel companies see the value of including additional drivers, such as conference space. Future iterations of this work will further explore drivers of energy use variation, but in this report, we corrected for the following three main drivers: size or number of rooms, location or weather, and chain scale segment. These were decided upon in a collaborative discussion with the participating hotel companies.

---

11 *Evaluation of Savings in Energy-Efficient Public Housing in the Pacific Northwest*. US Department of Energy, 16-17.

12 We thank a helpful reviewer for emphasizing the need to identify drivers of energy use.

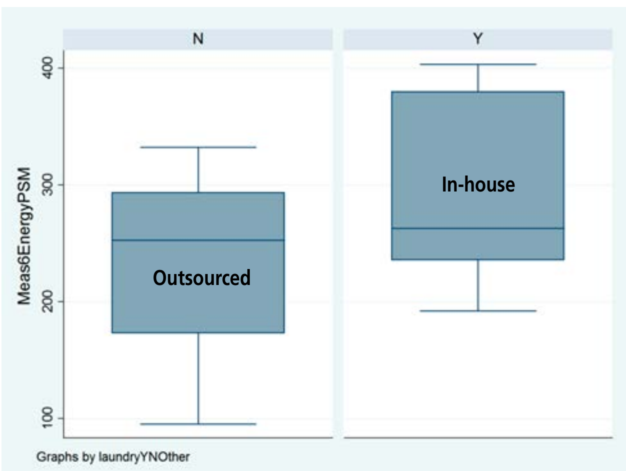
Exhibit 9

Breakdown of laundry wash (*n* = 421 hotels)

Segment	Laundry wash identified	Included in utility data (Laundry In-house)	Not included in utility data (Laundry outsourced)	Percentage included
Economy/Midscale/Upper Midscale	83	35	48	42%
Upscale/Upper Upscale/ Luxury	338	261	77	77%
Total	421	296	125	70%

Exhibit 10

Distribution of energy intensity among hotels in one U.S. city, with and without laundry wash



Based on the data we received, we explore the following drivers of general energy variation: laundry wash, room size, and HVAC usage analysis. The quantifiable contributions of each additional driver individually and collectively will be a key focus of subsequent studies, where geographic-level multivariate regression analysis can be performed.

Laundry Wash

There's little doubt that the handling of laundry wash would influence a hotel's energy consumption, but the specific effect is difficult to isolate. Exhibit 9 presents how 421 hotels (about 25% of hotels in the sample) indicated the property status of laundry wash.[13] Of those, about three-fourths of hotels handle laundry in-house, with upscale hotels more likely to wash laundry in-house. Because data were insufficient to determine laundry usage in the data set, we did not add in any factors to the HCMI metrics to account for outsourced laundry. This is an opportunity for improvement in the next study, and we used this year's data to analyze the contribution of laundry to a hotel's energy footprint for the data available.

To attempt to analyze the contribution of laundry wash to a hotel's energy usage the most straightforward solution would be to sub-meter laundry facilities' usage and analyze the data across a representative sample. Even without sub-metered laundry data, there are two broad analytical approaches: the bottom-up approach and the top-down approach. The bottom-up approach adds up the amount of laundry used, determines drivers of this laundry use, and looks at the energy per unit of laundry (which may vary based on technology). We use a top-down approach, however, which looks at total energy use and attempts to infer the energy used for laundry based on variation in laundry use across hotels.

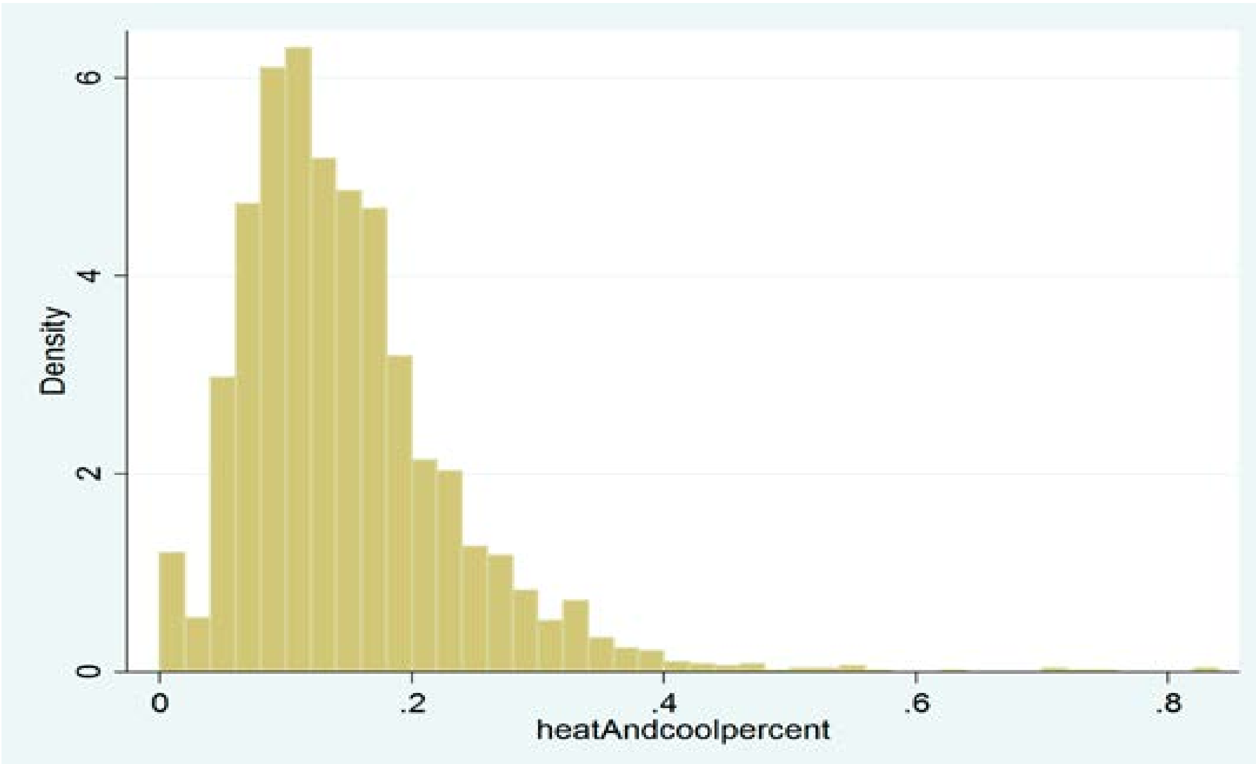
A simple, illustrative example of the top-down approach is given in Exhibit 10. These represent the distribution of energy per square meter (in kWh) between those who outsource laundry (N) and those who handle it in-house (Y) for upscale or higher hotels in one major U.S. metropolitan city. There is considerable overlap in the distributions. Secondly, there are fewer than 10 observations in each group. Third, since these are of the same segment and geography, climate and segment are not driving the difference. However, there are other drivers of energy use even within this segmentation that could drive the effect. The difference in the averages is about 30 percent, but it is not statistically sound to infer a 30 percent variation.

The top-down approach can be applied to the global dataset using statistical analysis. Multivariate regression analysis was run to see at what level those hotels that do laundry in-house see an increase in total energy use normalized to the hotel indoor area (Energy PSM). Using controls for city and segment and allowing laundry's impact to vary across the segments, laundry had a 14 percent (plus or minus 50 percent) increase for upper midscale and below and an 8 percent (plus or minus 50 percent) increase in energy per

13 We recognize that partial laundry wash exists in-house in some instances. However, properties that outsourced or washed bed linens and towels at an offsite location were considered to be outsourced.

Exhibit 11

Inferred heating and cooling as a percentage of total energy consumption



area unit compared to those without an in-house laundry (for chain scale segments of upscale and higher). The wide margin of error is due to the wide variation in the overall energy usage of hotels and the small number of hotels.

Peak, Heating, and Cooling Use Percentages

Although annual data are used for reporting and benchmarking in many cases, monthly utility data are extremely valuable in understanding what energy savings are likely. In fact, ASHRAE energy audit guidelines state that monthly utility bill analysis is an essential first step.[14]

Using the sample, we have effectively run a utility bill analysis for more than 2,000 hotels in dozens of countries and climate zones. We split the monthly data into cooling and heating months, and computed baseline energy usage. Exhibit 11 plots the inferred heating and cooling (usage above baseline) as a percentage of total use; in a year, the average hotel uses about 13 percent of energy use on heating and cooling. We found wide variation, mostly due to climatic differences, but a surprisingly large amount of the variation is not because of climate.

Exhibit 12 (next page) shows the variation within geography and segment of inferred HVAC as a percentage of total use.[15] Variation within a geography and a segment is largely driven by the physical assets and HVAC and building thermal system. High values within a geography indicate buildings that have high potential for cost-effective retrofits. Those with lower values within a geography are buildings with well-performing thermal control systems. For the cluster of hotels with inferred HVAC at zero, our bill analysis could not clearly distinguish HVAC usage from other normal usage using monthly data. This does not mean that HVAC was not used. A typical property has a winter peak and a summer peak. Irregular usage patterns would represent data quality issues, a seasonal use pattern, or an atypical climate profile.

Taking New York City's upscale and luxury hotels as an example, the median hotel had 18 percent of its energy use applied to heating, cooling, and ventilation. Most hotels were within 25- to 75-percent of this figure, with 11 percent to 22 percent of energy for HVAC. We see, then, that 25

14 ASHRAE 2011 Handbook, HVAC Applications. Chapter 36, Energy Use and Management.

15 Inferred HVAC refers to the heating and cooling which is higher utility usage in some months (hot or cold) compared to other months (mild weather). HVAC systems are almost always operating, and large buildings typically have continuously running ventilation systems.

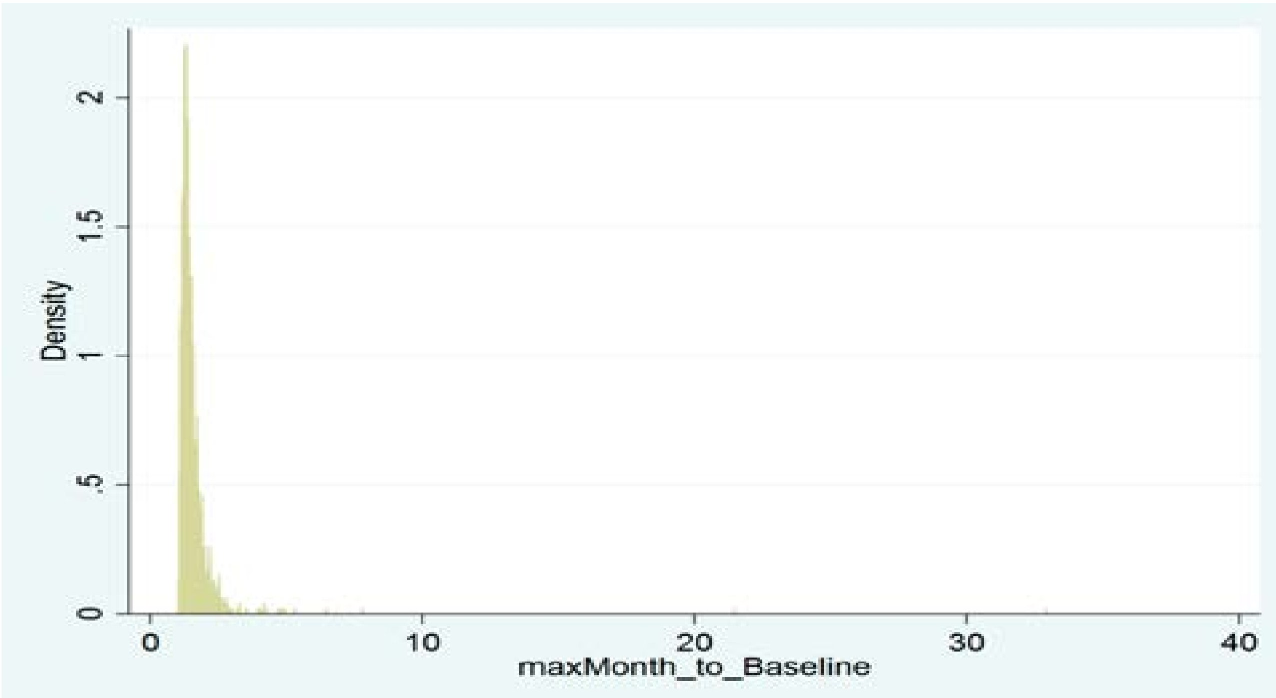
Exhibit 12

Inferred HVAC as a percentage of total use by geography and segment

City	Sample size	Median HVAC energy percentage	25-75 interval
Upper Midscale or Lower (n = 34)			
Chicago	11	15%	11%-24%
Dallas	12	15%	12%-17%
Minneapolis	11	15%	14%-23%
Upscale and Higher (n = 1,049)			
Atlanta	48	10%	7%-14%
Austin	18	10%	8%-12%
Baltimore	18	13%	11%-20%
Beijing	11	21%	16%-25%
Boston	43	18%	13%-25%
Charlotte	13	8%	7%-11%
Chicago	59	20%	16%-24%
Cincinnati	17	14%	12%-20%
Cleveland	10	17%	13%-21%
Dallas	49	12%	9%-17%
Denver	27	16%	13%-19%
Detroit	17	22%	17%-27%
Houston	34	12%	6%-16%
Indianapolis	18	16%	11%-19%
Jacksonville, FL	16	12%	10%-14%
Kansas City	17	15%	13%-20%
London	11	15%	11%-21%
Los Angeles	60	7%	5%-9%
Louisville, KY	10	15%	13%-17%
Miami	38	7%	5%-12%
Minneapolis	11	19%	9%-30%
Nashville	14	12%	8%-20%
New Orleans	14	8%	6%-11%
New York	70	18%	11%-22%
Orlando	21	11%	7%-13%
Philadelphia	33	16%	10%-21%
Phoenix	39	11%	7%-14%
Portland	12	13%	7%-17%
Richmond, VA	14	14%	11%-18%
Riverside-San Bernardino-Ontario, CA	10	9%	9%-9%
Sacramento	12	8%	7%-11%
San Antonio	19	14%	10%-23%
San Diego	27	7%	6%-10%
San Francisco	38	8%	6%-10%
Seattle	22	13%	9%-18%
Shanghai	18	20%	18%-24%
St. Louis	13	13%	8%-19%
Tampa-St. Petersburg-Clearwater, FL	25	11%	6%-13%
Virginia Beach-Norfolk-Newport News, VA-NC	18	14%	10%-20%
Washington, DC	85	12%	9%-16%

Exhibit 13

Distribution among sample of the ratio of peak energy month to baseline



percent of hotels had HVAC usage higher than 22 percent. These hotels are prime candidates for energy retrofits that may save the hotel money in the long run.

We did see the expected pattern that hotels in milder climates (e.g., California, with 9% median HVAC usage) have lower HVAC usage than those in harsher climates (e.g., Detroit and Chicago with 20 to 22% median HVAC usage). The table is essential in determining whether the HVAC usage percentage is high, depending on the geography. Fourteen percent would characterize a high-usage, wasteful building in California, but that would describe a low-usage building in Detroit and Chicago.

International comparisons can also be helpful. Shanghai and Beijing have higher median usage than U.S. cities with corresponding climate zones (e.g., D.C. and Boston). Hence, hotels in Shanghai and Beijing may have potential for large energy savings. Part of this picture is that cheaper energy costs in China may also indicate less financial incentive to pursue efficiency, hence the higher usage numbers.

HVAC percentage also provides an easy data-check method. Extreme outliers (<2% and >50%) are likely to be errors in data reporting or data processing or both. Gathering monthly data also allows analysis of the largest energy usage month to the baseline. The global distribution is shown in Exhibit 13. The median hotel has a peak of 1.4 times the baseline. Ten percent of hotels in the data set use 1.9 times or more of their baseline usage in their highest month. Although one would expect most of this variation to be across climate, a surprising amount of this variation occurs within a geography and segment.

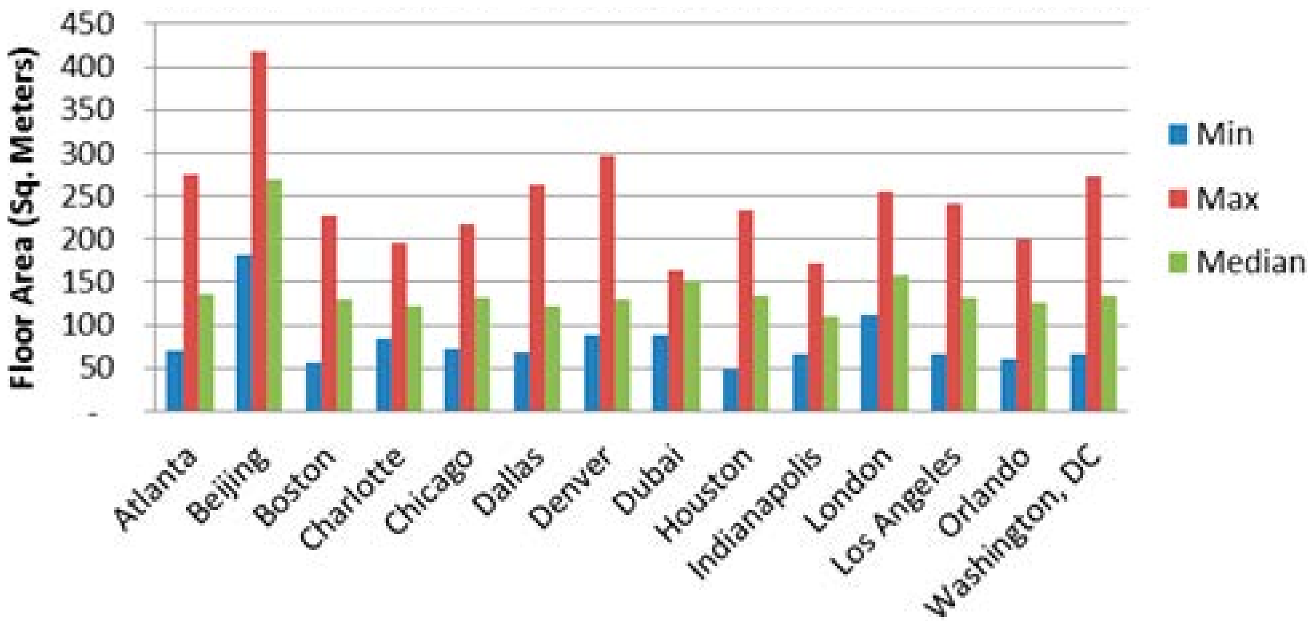
In this peak month, the building is operating under its highest thermal stress. Since buildings in the same geography face the same weather, this "peak" usage can also reveal which buildings perform better. Again using New York upscale and luxury hotels as an example, the median hotel has a peak of 1.5 times the baseline, but 10 percent of hotels use 2.0 times the baseline.

Utility bill analysis is not a substitute for engineering analysis. Building science tells us, for example, that more compact buildings lose less heat in the winter than narrow buildings.[16] Hence, both the HVAC percentage and peak-month values may be higher for a reason that is not

[16] For example, see: John F. Straube, "The Function of Form: Building Shape and Energy," *High Performance Enclosures* (Somerville, MA: Building Science Press: 2012); and Francis D.K. Ching and Ian M. Shapiro, *Green Building Illustrated* (New York: Wiley, 2014).

Exhibit 14

Range of floor area (guestrooms and corridors) per room among select geographies



easily changeable (e.g., the shape of a building). However, the utility-bill analysis is simple and quick. Combined with benchmarking, these can help identify buildings that can be more energy efficient.

Variation in HCMI Room Size

Variation in HCMI figures as well as energy per occupied room can also be explained when considering the varying floor area of guestrooms globally and within specific markets. We divided the HCMI rooms and corridors allocation of the hotel by the number of rooms, as presented in Exhibit 14. Analyzing these results, it is important to note that though the median values generally fall within similar ranges across geographies, a significant range exists within each geography. This may be due to room size as well as the amount of public areas and back of house areas lumped into the calculation.

Standardized Emission Factors

This study also seeks to provide clarity on carbon emissions in hotels by using standardized emission factors for the entire data set. One current limitation to comparability in the general current state of carbon calculation in facilities is the disparate use of emission factors in the calculation. The choice of diverse emission factors and assumptions inhibit comparison and uniform footprinting, and the science and precision of arriving at carbon factors and global warming potential itself is subject to a high degree of uncertainty and disagreement, as has been noted in other studies.[17] For example, the use of regional emission factors rather than national factors in the United States could sway the hotel's footprint by a factor of 3 or more. Furthermore, emission factors are constantly changing as data sets are updated, and even if the same reference for emission factors is the same, using different years of a reference's publication can cause variation. Thus, for enabling the use of carbon benchmarks, it is more important that the entire industry use the same factors than to constantly seek maximum perceived precision for factors themselves derived from inherent uncertainty.

Renewable Energy

An increasing number of hotels are running at least partially on renewable energy. Slightly over 100 hotels indicated renewable energy sources as part of their energy usage, but data reporting quality varied across properties. What was not represented in the data is also the increasing percentage of renewable or low-carbon energy being fed into the electricity grid in certain countries. As renewable energy mandates become more prevalent, the distribution of low-carbon energy will be more interesting to study. This will average out across a country or region with the same specific sources of energy generation. On the other hand, analysis

[17] See: Eric Ricaurte, "Determining Materiality in Carbon Footprinting: What Counts and What Does Not," *Cornell Hospitality Report,* Vol. 12, No. 12 (September 2012) Cornell Center for Hospitality Research, pp. 11–12.

Exhibit 15

Research limitations and opportunities

Issue	Description	Limitations and approaches
Fugitive Emissions and Mobile Fuels Data	Some participating companies included fugitive emissions and mobile fuels in their data sets, while some did not.	The contribution of fugitive emissions to carbon footprints was not analyzed in this study. In future years fugitive emissions may be added to the carbon footprint metrics. This may be collected if valuable to the group, also enabling analysis of which types of facilities generate more emissions and how that may influence footprints.
Collapsed Segmentation	Using a threshold of 10 properties per segment, sufficient data were not available in most cases for presentation of results separately within each segment.	Segments were collapsed into two categories only for this study: Economy/Midscale/Upper Midscale, and Upscale/Upper Upscale/Luxury.
		As the sample was limited to data provided by hotel companies, the independent segment was not analyzed.
		In future studies, larger data sets will enable further segmentation.
Other Energy Drivers	Several energy drivers, such as type of amenities present within the hotel's utility data set, were not analyzed. Furthermore, humidity is often a driver of energy and was not factored into the analysis.	In future studies, the researchers will work with the advisory group to define additional variables to include in the data collection for analysis to support modeling. Key opportunities are restaurants, swimming pools, humidity, and further clarity on laundry wash.
Geographies across Countries and Regions	Collapsing the data set into geographies that span entire countries limits the usefulness of the carbon benchmarks, as emissions per kWh of electricity vary widely across countries.	Hotels in countries with fewer than 10 properties were excluded from the published results. With more robust data, more markets and countries can be added each year.
Hotel Location Segment	The business types of hotels were not analyzed (e.g., suburban, airport, resort) in this study but may offer further insight when analyzed.	Future studies can include data capture on location segments for analysis.
Data Verification	Data submitted were self-reported.	All self-reported data were accepted for this year's study, with a validity check for completeness and extreme outliers being the only control used.
		For future studies, participating companies should indicate whether and how data have been verified. A minimum threshold of data verification processes may be added as a validity test.
Monthly Energy Data Calendar Parameters	Monthly energy consumption figures are either normalized by the participating company (or provider) to match calendar days exactly, or use billing cycles which are a proximate but imperfect match.	As a first year, the researchers did not seek to standardize exact calendar matches for monthly data received.
		Each company submitted their energy data as they currently have it prepared by month, indicating what the months represent (whether normalized to match calendar days, smoothed, or raw from utility billing cycles, or unknown).
Purchased Chilled Water Emission Factors	Default data and research on emission factors for chilled water across a global data set are inconsistent.	A default method for calculating emissions from purchased chilled water was used per the US EIA's guidance on Voluntary Reporting of Greenhouse Gas Emissions arriving at an emission factor as a function of the emission factors for electricity generation per country.
		For future studies, further granularity will be sought by the researchers in applying factors for chilled water.
Purchased Steam and Heat Emission Factors	Default data and research on emission factors for purchased steam or heat across a global data set is inconsistent.	For this year's study, a default emission factor of purchased steam or heat was applied to all properties globally when purchased steam or heat was used (per the US EIA's guidance on Voluntary Reporting of Greenhouse Gas Emissions).
		For future studies, further granularity will be sought for emission factors for purchased steam, requesting support from all participating companies to provide the respective COP or Emission Factors when provided by the utility.

should distinguish hotels that are purchasing or generating renewable energy.

Limitations and Opportunities

This study's overall limitation is at the same time its greatest opportunity. The data sets presented are not necessarily actionable due to the additional set of factors to consider when examining performance in energy usage and carbon emissions. In arriving at a unified, globally representative data set with significant industry participation, however, the opportunity exists to further expand, refine, and improve the data set and benchmarking methods each year. Increased participation from additional companies as well as increased availability of complete data within current companies will greatly strengthen the data set.

As such, for next year's figures, the data set and geographies themselves may change, as may new agreements to harmonize the emission factors used. Therefore, year-over-year comparisons may not be practical in the short term. Additionally a number of limitations and opportunities for future studies were identified, as summarized in Exhibit 15. The benchmarks for the six measures follow, in Exhibits 16 through 21.

Continued Progress

Over the past few years, great strides have been made both externally and internally to enable hotels to consistently report the energy consumption and carbon footprint of a guestroom. Paramount collaboration has carried forth the researching, standardizing, and submitting data to enable better carbon measurement. Better data sets will increase the value of this study and its applications as the process continually improves. As benchmarks become standardized and more widespread, the important next step is to disseminate this information. Too often data are reported from hotels to a central location, but the hotel never sees how it is used or helps the company. Furthermore, the move can be made beyond just reporting to using the data for continuous improvement and ultimately achieving the goal of reducing energy consumption and carbon emissions at each hotel property and for the industry as a whole.

Finally, benchmarking in the hotel industry has tended to lean toward reliance on single tell-all numbers such as RevPAR. However when analyzing energy and carbon, it is important to recognize the complexity that affects performance. While rigorous statistical analysis can enable valid regression models to make proper comparisons, there's little chance that a single number will be all-telling for whether a property is managing its energy and carbon footprint well. A series of specifications, processes, and other factors are involved and collectively form the managerial approach to benchmarking. ■

Looking Ahead to the 2014 Study

The 2014 Cornell HSB study will open in June 2014, with results produced in the fall of 2014. Eligible companies will be invited to participate. Based on the number of participating companies, CHSB may limit additions to the advisory group. Interested parties may contact Eric Ricaurte (eer3@cornell.edu) for further information.

Exhibit 16

Measure 1: HCMI rooms footprint per occupied room (kg)

GEOGRAPHY		Economy/Midscale/Upper Midscale					Upscale/Upper Upscale/Luxury				
Region	Country	Count	High	Median	Low	SD	Count	High	Median	Low	SD
Atlanta	USA	N/A	N/A	N/A	N/A	N/A	38	81.9	30.0	17.8	13.2
Baltimore	USA	N/A	N/A	N/A	N/A	N/A	11	33.8	19.0	16.2	5.9
Boston	USA	N/A	N/A	N/A	N/A	N/A	23	81.1	19.9	14.4	13.8
Charlotte	USA	N/A	N/A	N/A	N/A	N/A	12	27.9	18.2	15.3	4.9
Chicago	USA	N/A	N/A	N/A	N/A	N/A	53	112.8	30.1	20.2	18.0
CHINA		16	100.9	43.8	7.6	24.5	23	235.0	122.7	62.9	50.7
Cincinnati	USA	N/A	N/A	N/A	N/A	N/A	17	56.4	29.8	24.3	7.9
Dallas	USA	N/A	N/A	N/A	N/A	N/A	35	62.3	26.6	17.1	9.9
Denver	USA	N/A	N/A	N/A	N/A	N/A	19	52.5	30.3	22.7	10.0
Detroit	USA	N/A	N/A	N/A	N/A	N/A	13	49.2	28.1	23.2	6.5
Hong Kong-Shenzhen-Macau	CHINA	N/A	N/A	N/A	N/A	N/A	7	298.5	107.3	40.7	85.0
Houston	USA	N/A	N/A	N/A	N/A	N/A	26	57.9	27.3	20.1	10.7
Indianapolis	USA	N/A	N/A	N/A	N/A	N/A	12	51.4	26.1	19.0	10.0
Kansas City	USA	N/A	N/A	N/A	N/A	N/A	12	68.4	37.7	26.2	11.9
Los Angeles	USA	N/A	N/A	N/A	N/A	N/A	23	47.2	16.2	12.2	7.6
Miami	USA	N/A	N/A	N/A	N/A	N/A	28	84.8	28.3	16.1	14.5
New Orleans	USA	N/A	N/A	N/A	N/A	N/A	11	36.8	29.3	15.7	6.2
New York City	USA	N/A	N/A	N/A	N/A	N/A	44	54.4	18.6	9.3	9.5
Orlando	USA	N/A	N/A	N/A	N/A	N/A	15	44.4	23.8	16.4	8.3
Philadelphia	USA	N/A	N/A	N/A	N/A	N/A	24	44.1	19.0	15.1	8.1
Phoenix	USA	N/A	N/A	N/A	N/A	N/A	31	54.8	25.8	18.4	11.1
San Antonio	USA	N/A	N/A	N/A	N/A	N/A	15	53.3	29.8	19.8	10.0
San Diego	USA	N/A	N/A	N/A	N/A	N/A	15	65.8	18.1	6.8	13.0
San Francisco	USA	N/A	N/A	N/A	N/A	N/A	14	29.9	14.7	9.2	5.6
Seattle	USA	N/A	N/A	N/A	N/A	N/A	14	34.9	20.6	15.2	5.1
Tampa	USA	N/A	N/A	N/A	N/A	N/A	17	64.4	23.8	19.3	12.2
USA		106	80.3	22.6	5.5	11.2	1,015	112.8	25.1	6.8	12.3
UNITED KINGDOM*							11	41.6	23.9	2.6	12.8
Virginia Beach	USA	N/A	N/A	N/A	N/A	N/A	17	66.7	23.6	17.9	11.4
Washington, DC	USA	N/A	N/A	N/A	N/A	N/A	64	59.7	23.3	16.7	8.2

*All segments collapsed

Exhibit 17

Measure 2: Hotel carbon footprint per room (kg)

GEOGRAPHY		Economy/Midscale/Upper Midscale					Upscale/Upper Upscale/Luxury				
Region	Country	Count	High	Median	Low	SD	Count	High	Median	Low	SD
Atlanta	USA	N/A	N/A	N/A	N/A	N/A	38	20,115.4	9,102.4	5,196.8	3,738.9
Baltimore	USA	N/A	N/A	N/A	N/A	N/A	11	9,848.0	5,194.1	4,250.7	1,940.8
Boston	USA	N/A	N/A	N/A	N/A	N/A	23	22,401.5	6,037.4	4,261.9	3,675.3
Charlotte	USA	N/A	N/A	N/A	N/A	N/A	12	8,534.7	5,348.1	4,270.3	1,677.7
Chicago	USA	N/A	N/A	N/A	N/A	N/A	53	29,750.4	8,660.0	5,709.1	5,042.1
CHINA		16	18,812.9	13,229.8	1,990.5	5,684.5	23	71,473.3	26,171.8	15,271.1	14,256.8
Cincinnati	USA	N/A	N/A	N/A	N/A	N/A	17	16,883.9	7,772.8	5,498.8	2,592.7
Dallas	USA	N/A	N/A	N/A	N/A	N/A	35	14,341.6	6,582.2	4,335.6	2,997.4
Denver	USA	N/A	N/A	N/A	N/A	N/A	19	17,754.7	8,657.2	6,309.3	3,299.5
Detroit	USA	N/A	N/A	N/A	N/A	N/A	13	14,919.0	7,877.8	6,695.0	2,165.3
Hong Kong-Shenzhen-Macau	CHINA	N/A	N/A	N/A	N/A	N/A	7	50,010.1	29,671.1	9,903.0	14,379.0
Houston	USA	N/A	N/A	N/A	N/A	N/A	26	18,659.7	8,932.6	4,431.2	3,709.3
Indianapolis	USA	N/A	N/A	N/A	N/A	N/A	12	14,856.9	7,291.1	4,929.2	3,098.9
Kansas City	USA	N/A	N/A	N/A	N/A	N/A	12	17,172.0	10,116.4	7,455.6	3,298.6
Los Angeles	USA	N/A	N/A	N/A	N/A	N/A	23	14,556.3	4,956.6	3,707.0	2,577.7
Miami	USA	N/A	N/A	N/A	N/A	N/A	28	22,151.1	9,063.6	5,059.7	3,816.1
New Orleans	USA	N/A	N/A	N/A	N/A	N/A	11	11,608.0	8,357.0	4,593.8	1,978.1
New York City	USA	N/A	N/A	N/A	N/A	N/A	44	15,092.7	5,847.4	2,678.0	2,937.4
Orlando	USA	N/A	N/A	N/A	N/A	N/A	15	13,770.5	7,202.8	5,051.0	3,275.1
Philadelphia	USA	N/A	N/A	N/A	N/A	N/A	24	12,045.0	5,154.9	4,219.3	2,532.0
Phoenix	USA	N/A	N/A	N/A	N/A	N/A	31	16,323.4	5,940.9	4,558.6	3,761.9
San Antonio	USA	N/A	N/A	N/A	N/A	N/A	15	16,685.3	7,711.6	5,232.2	3,518.7
San Diego	USA	N/A	N/A	N/A	N/A	N/A	15	16,764.8	6,175.5	2,012.2	3,135.3
San Francisco	USA	N/A	N/A	N/A	N/A	N/A	15	9,648.4	5,022.1	2,938.5	1,695.8
Seattle	USA	N/A	N/A	N/A	N/A	N/A	14	11,310.4	6,251.7	4,399.4	1,844.2
Tampa	USA	N/A	N/A	N/A	N/A	N/A	17	18,875.3	6,574.0	4,813.9	4,147.0
USA		107	24,410.1	5,509.2	1,503.2	3,002.0	1,017	30,642.4	6,964.6	2,012.2	3,524.5
UNITED KINGDOM*							12	13,377.2	6,331.4	647.2	3,927.1
Virginia Beach	USA	N/A	N/A	N/A	N/A	N/A	17	16,556.6	6,407.0	4,398.0	2,858.9
Washington, DC	USA	N/A	N/A	N/A	N/A	N/A	68	15,850.4	6,587.5	4,143.6	2,494.2

*All segments collapsed

Exhibit 18

Measure 3: Hotel carbon footprint per occupied room (kg)

GEOGRAPHY		Economy/Midscale/Upper Midscale					Upscale/Upper Upscale/Luxury				
Region	Country	Count	High	Median	Low	SD	Count	High	Median	Low	SD
Atlanta	USA	N/A	N/A	N/A	N/A	N/A	38	90.0	34.0	18.1	16.2
Baltimore	USA	N/A	N/A	N/A	N/A	N/A	11	37.2	19.4	16.2	7.5
Boston	USA	N/A	N/A	N/A	N/A	N/A	23	83.5	21.9	14.6	14.2
Charlotte	USA	N/A	N/A	N/A	N/A	N/A	12	31.7	18.5	15.5	6.1
Chicago	USA	N/A	N/A	N/A	N/A	N/A	53	116.2	33.2	20.4	19.9
CHINA		16	115.2	49.3	7.7	27.6	23	285.0	138.2	63.8	62.9
Cincinnati	USA	N/A	N/A	N/A	N/A	N/A	17	64.4	31.4	24.9	10.3
Dallas	USA	N/A	N/A	N/A	N/A	N/A	35	77.9	27.2	17.9	12.9
Denver	USA	N/A	N/A	N/A	N/A	N/A	19	61.6	31.1	22.9	12.8
Detroit	USA	N/A	N/A	N/A	N/A	N/A	13	59.4	29.3	23.4	9.0
Hong Kong-Shenzhen-Macau	CHINA	N/A	N/A	N/A	N/A	N/A	7	314.8	109.3	42.0	90.6
Houston	USA	N/A	N/A	N/A	N/A	N/A	26	69.0	32.2	20.3	14.4
Indianapolis	USA	N/A	N/A	N/A	N/A	N/A	12	56.0	26.8	19.5	12.5
Kansas City	USA	N/A	N/A	N/A	N/A	N/A	12	86.3	38.3	27.6	16.1
Los Angeles	USA	N/A	N/A	N/A	N/A	N/A	23	49.5	17.3	12.8	8.7
Miami	USA	N/A	N/A	N/A	N/A	N/A	28	90.4	30.5	20.2	16.1
New Orleans	USA	N/A	N/A	N/A	N/A	N/A	11	43.9	30.6	16.4	7.7
New York City	USA	N/A	N/A	N/A	N/A	N/A	44	56.0	19.7	9.6	10.5
Orlando	USA	N/A	N/A	N/A	N/A	N/A	15	60.5	24.3	18.2	14.2
Philadelphia	USA	N/A	N/A	N/A	N/A	N/A	24	46.4	19.4	16.0	9.4
Phoenix	USA	N/A	N/A	N/A	N/A	N/A	31	82.2	26.4	18.9	16.0
San Antonio	USA	N/A	N/A	N/A	N/A	N/A	15	68.1	30.7	20.3	15.2
San Diego	USA	N/A	N/A	N/A	N/A	N/A	15	76.7	21.9	6.9	15.1
San Francisco	USA	N/A	N/A	N/A	N/A	N/A	14	33.6	16.1	9.3	6.4
Seattle	USA	N/A	N/A	N/A	N/A	N/A	14	38.0	22.8	15.8	5.9
Tampa	USA	N/A	N/A	N/A	N/A	N/A	17	67.1	24.5	20.1	14.3
USA		108	96.5	22.9	1.4	12.4	1,015	134.1	26.3	6.9	14.7
UNITED KINGDOM*							11	44.6	27.8	2.7	14.4
Virginia Beach	USA	N/A	N/A	N/A	N/A	N/A	17	75.7	23.9	20.5	13.8
Washington, DC	USA	N/A	N/A	N/A	N/A	N/A	64	67.2	25.4	16.9	10.6

*All segments collapsed

Exhibit 19

Measure 4: Hotel carbon footprint per square meter (kg)

GEOGRAPHY		Economy/Midscale/Upper Midscale					Upscale/Upper Upscale/Luxury				
Region	Country	Count	High	Median	Low	SD	Count	High	Median	Low	SD
Atlanta	USA	N/A	N/A	N/A	N/A	N/A	38	196.4	124.0	80.9	28.0
Baltimore	USA	N/A	N/A	N/A	N/A	N/A	11	143.9	98.2	79.2	19.4
Boston	USA	N/A	N/A	N/A	N/A	N/A	23	194.2	89.0	49.8	31.0
Charlotte	USA	N/A	N/A	N/A	N/A	N/A	12	145.7	83.9	73.1	25.0
Chicago	USA	N/A	N/A	N/A	N/A	N/A	53	348.9	142.4	97.2	47.0
CHINA		16	699.7	106.8	53.1	200.4	23	369.5	209.2	72.3	77.0
Cincinnati	USA	N/A	N/A	N/A	N/A	N/A	17	181.5	132.2	97.2	26.5
Dallas	USA	N/A	N/A	N/A	N/A	N/A	35	196.6	105.3	73.6	28.3
Denver	USA	N/A	N/A	N/A	N/A	N/A	19	208.0	140.6	91.4	35.8
Detroit	USA	N/A	N/A	N/A	N/A	N/A	13	202.2	139.9	103.7	27.3
Hong Kong-Shenzhen-Macau	CHINA	N/A	N/A	N/A	N/A	N/A	7	328.4	215.9	105.9	82.9
Houston	USA	N/A	N/A	N/A	N/A	N/A	26	264.1	129.7	83.1	43.4
Indianapolis	USA	N/A	N/A	N/A	N/A	N/A	12	199.0	143.8	94.7	28.6
Kansas City	USA	N/A	N/A	N/A	N/A	N/A	12	227.9	150.3	120.9	29.8
Los Angeles	USA	N/A	N/A	N/A	N/A	N/A	23	188.8	65.6	37.1	32.9
Miami	USA	N/A	N/A	N/A	N/A	N/A	28	201.9	141.6	87.0	32.7
New Orleans	USA	N/A	N/A	N/A	N/A	N/A	11	142.9	119.3	113.2	9.2
New York City	USA	N/A	N/A	N/A	N/A	N/A	44	236.3	95.6	39.3	33.7
Orlando	USA	N/A	N/A	N/A	N/A	N/A	15	223.4	128.7	85.3	35.6
Philadelphia	USA	N/A	N/A	N/A	N/A	N/A	24	155.1	88.6	66.1	24.6
Phoenix	USA	N/A	N/A	N/A	N/A	N/A	31	189.9	107.7	81.3	27.2
San Antonio	USA	N/A	N/A	N/A	N/A	N/A	15	167.0	128.6	87.2	25.6
San Diego	USA	N/A	N/A	N/A	N/A	N/A	15	129.3	81.8	29.7	26.2
San Francisco	USA	N/A	N/A	N/A	N/A	N/A	14	90.2	62.9	51.4	12.7
Seattle	USA	N/A	N/A	N/A	N/A	N/A	14	104.4	83.0	62.4	11.4
Tampa	USA	N/A	N/A	N/A	N/A	N/A	17	194.3	116.6	84.7	31.5
USA		109	389.8	116.8	20.4	62.0	1,016	348.9	114.6	22.4	36.6
UNITED KINGDOM*							11	254.3	109.5	6.7	87.9
Virginia Beach	USA	N/A	N/A	N/A	N/A	N/A	17	204.6	98.1	78.1	34.5
Washington, DC	USA	N/A	N/A	N/A	N/A	N/A	64	196.1	104.6	69.2	26.2

*All segments collapsed

Exhibit 20

Measure 5: Hotel energy footprint per occupied room (kWh)

GEOGRAPHY		Economy/Midscale/Upper Midscale					Upscale/Upper Upscale/Luxury				
Region	Country	Count	High	Median	Low	SD	Count	High	Median	Low	SD
Atlanta	USA	N/A	N/A	N/A	N/A	N/A	38	207.0	79.9	41.6	41.0
Baltimore	USA	N/A	N/A	N/A	N/A	N/A	11	114.8	60.2	50.2	21.9
Boston	USA	N/A	N/A	N/A	N/A	N/A	23	270.1	83.3	56.9	44.7
Charlotte	USA	N/A	N/A	N/A	N/A	N/A	12	90.1	52.0	42.4	17.4
Chicago	USA	N/A	N/A	N/A	N/A	N/A	53	221.2	69.4	46.0	46.5
CHINA		16	344.6	92.6	12.8	77.5	23	835.3	298.4	103.7	164.5
Cincinnati	USA	N/A	N/A	N/A	N/A	N/A	17	139.2	62.0	54.5	24.9
Dallas	USA	N/A	N/A	N/A	N/A	N/A	35	167.6	61.6	46.9	32.4
Denver	USA	N/A	N/A	N/A	N/A	N/A	19	151.4	60.2	41.4	33.2
Detroit	USA	N/A	N/A	N/A	N/A	N/A	13	122.5	57.8	47.3	19.2
Hong Kong-Shenzhen-Macau	CHINA	N/A	N/A	N/A	N/A	N/A	7	474.9	233.8	138.7	112.8
Houston	USA	N/A	N/A	N/A	N/A	N/A	26	207.7	77.6	47.4	42.5
Indianapolis	USA	N/A	N/A	N/A	N/A	N/A	12	145.3	57.2	46.1	30.7
Kansas City	USA	N/A	N/A	N/A	N/A	N/A	12	113.9	66.0	48.8	20.7
Los Angeles	USA	N/A	N/A	N/A	N/A	N/A	23	201.4	72.5	51.2	35.5
Miami	USA	N/A	N/A	N/A	N/A	N/A	28	232.6	73.7	45.6	41.1
New Orleans	USA	N/A	N/A	N/A	N/A	N/A	11	134.2	91.0	47.4	26.2
New York City	USA	N/A	N/A	N/A	N/A	N/A	44	214.5	69.4	38.7	40.8
Orlando	USA	N/A	N/A	N/A	N/A	N/A	15	148.2	62.7	43.6	34.4
Philadelphia	USA	N/A	N/A	N/A	N/A	N/A	24	169.8	57.8	48.7	32.6
Phoenix	USA	N/A	N/A	N/A	N/A	N/A	31	192.3	65.5	47.3	39.2
San Antonio	USA	N/A	N/A	N/A	N/A	N/A	15	168.7	78.4	46.2	44.3
San Diego	USA	N/A	N/A	N/A	N/A	N/A	15	322.5	87.7	24.3	64.3
San Francisco	USA	N/A	N/A	N/A	N/A	N/A	14	142.0	66.7	38.9	28.7
Seattle	USA	N/A	N/A	N/A	N/A	N/A	14	114.8	78.4	55.7	15.2
Tampa	USA	N/A	N/A	N/A	N/A	N/A	17	144.4	61.0	46.8	30.7
USA		106	404.8	51.3	13.4	55.4	1,015	339.6	64.6	24.3	38.6
UNITED KINGDOM*							11	162.0	96.0	7.4	52.5
Virginia Beach	USA	N/A	N/A	N/A	N/A	N/A	17	229.8	62.8	54.8	44.0
Washington, DC	USA	N/A	N/A	N/A	N/A	N/A	64	203.3	72.3	45.6	31.9

*All segments collapsed

Exhibit 21

Measure 6: Hotel energy footprint per square meter (kWh)

GEOGRAPHY		Economy/Midscale/Upper Midscale					Upscale/Upper Upscale/Luxury				
Region	Country	Count	High	Median	Low	SD	Count	High	Median	Low	SD
Atlanta	USA	N/A	N/A	N/A	N/A	N/A	38	518.7	283.4	184.7	79.7
Baltimore	USA	N/A	N/A	N/A	N/A	N/A	11	448.7	288.7	229.1	64.9
Boston	USA	N/A	N/A	N/A	N/A	N/A	23	702.5	350.0	174.6	118.0
Charlotte	USA	N/A	N/A	N/A	N/A	N/A	12	404.2	229.4	196.1	72.6
Chicago	USA	N/A	N/A	N/A	N/A	N/A	53	676.1	320.7	210.8	102.4
CHINA		16	1,807.3	199.8	92.7	540.3	23	884.3	355.5	120.9	197.3
Cincinnati	USA	N/A	N/A	N/A	N/A	N/A	17	389.1	284.7	204.0	55.5
Dallas	USA	N/A	N/A	N/A	N/A	N/A	35	466.5	244.2	161.1	76.0
Denver	USA	N/A	N/A	N/A	N/A	N/A	19	516.2	265.5	168.3	98.1
Detroit	USA	N/A	N/A	N/A	N/A	N/A	13	420.3	281.1	209.9	66.0
Hong Kong-Shenzhen-Macau	CHINA	N/A	N/A	N/A	N/A	N/A	7	739.3	461.9	210.3	161.4
Houston	USA	N/A	N/A	N/A	N/A	N/A	26	820.9	300.8	205.4	134.8
Indianapolis	USA	N/A	N/A	N/A	N/A	N/A	12	475.3	303.7	243.0	63.7
Kansas City	USA	N/A	N/A	N/A	N/A	N/A	12	490.8	269.0	206.3	76.2
Los Angeles	USA	N/A	N/A	N/A	N/A	N/A	23	768.2	267.8	143.4	136.2
Miami	USA	N/A	N/A	N/A	N/A	N/A	28	487.0	323.7	192.1	82.0
New Orleans	USA	N/A	N/A	N/A	N/A	N/A	11	385.3	329.5	235.1	50.6
New York City	USA	N/A	N/A	N/A	N/A	N/A	44	901.7	326.1	179.3	138.6
Orlando	USA	N/A	N/A	N/A	N/A	N/A	15	490.9	306.8	220.0	77.5
Philadelphia	USA	N/A	N/A	N/A	N/A	N/A	24	508.8	258.3	197.0	92.6
Phoenix	USA	N/A	N/A	N/A	N/A	N/A	31	460.0	258.6	189.6	69.2
San Antonio	USA	N/A	N/A	N/A	N/A	N/A	15	561.8	329.2	198.2	91.9
San Diego	USA	N/A	N/A	N/A	N/A	N/A	15	543.7	321.5	105.1	116.1
San Francisco	USA	N/A	N/A	N/A	N/A	N/A	14	408.2	265.4	204.9	62.6
Seattle	USA	N/A	N/A	N/A	N/A	N/A	14	347.0	281.7	222.6	37.8
Tampa	USA	N/A	N/A	N/A	N/A	N/A	17	440.4	260.5	201.1	78.2
USA		109	1,571.2	260.3	52.2	211.8	1,016	901.7	277.8	105.1	85.9
UNITED KINGDOM*							11	878.5	296.6	18.6	329.6
Virginia Beach	USA	N/A	N/A	N/A	N/A	N/A	17	620.5	269.3	202.0	109.7
Washington, DC	USA	N/A	N/A	N/A	N/A	N/A	64	454.8	281.8	182.5	70.0

*All segments collapsed

Appendix: ***Data Preparation and Calculation Methods***

Segmentation

The researchers assigned a chain scale segment to each hotel per the 2013 U.S. Chain Scale Segment from STR.[1] The U.S. list was used as a proxy to determine global lists.

Square Footage

Square footage was requested in area of conditioned space

Energy Harmonization

All energy values were converted to kWh using commonly accepted conversion factors.

Purchased energy usage was calculated based on site energy boundary (not source energy) for the energy footprint values.

No additional conversions were made to energy data received, which were assumed to be representative of the hotel's actual utility usage.

GHG Emissions Calculation

Included within the calculation:

- Emissions from stationary combustion of fuels on-site
- Emissions from purchased electricity, heat, or steam
- Fugitive emissions and emissions from mobile fuel consumption were not included
- Sources of emission factors used:

Electricity

EPA eGRID version 2012 for all U.S. properties

IEA CO2 Emissions from Fuel Combustion (2012 Edition, updated March 2013) for all non-US properties

Purchased heat or steam: US Energy Information Administration Form EIA-1605 Appendix N

Purchased chilled water: US Energy Information Administration Form EIA-1605 Appendix N (assuming electric-driven chiller), applying country emission factors from IEA CO2 Emissions from Fuel Combustion (2012 Edition, updated March 2013).

Hong Kong Towngas – Hong Kong and China Gas Company Ltd., 2012.

All other fuels: World Resources Institute Stationary Combustion Tool 4.0

Data Verification

Data supplied by participating companies did not undergo a process of data verification. Researchers used the data received by companies, performing a validity test. The researchers did not review actual utility bills, occupancy data from PMS systems, or blueprints for square footage calculations. Each participating company may have a different approach to its data validation and verification, which was treated separate from this study and is the responsibility of each participating entity.

---

1 2013 STR Chain Scales: www.hotelnewsnow.com/chainscales.pdf

Cornell Center for Hospitality Research
Publication Index
chr.cornell.edu

Cornell University
School of Hotel Administration
The Center for Hospitality Research
537 Statler Hall
Ithaca, NY 14853

607.255.9780
shachr@cornell.edu

www.chr.cornell.edu